FORM PTO-1390 (Modified) (REV 11-2000) U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE

TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371

ATTORNEY'S DOCKET NUMBER	
70301/56912	
U.S. APPLICATION NO. (IF KNOWN, SEE 37 CFR	10/049305

INTERNATIONAL APPLICATION NO.	INTERNATIONAL FILING DATE	PRIORITY DATE CLAIMED
PCT/EP00/07318	July 28, 2000	August 6, 1999

TITLE OF INVENTION

PROCESS AND DEVICE FOR PRODUCING A THREE-DIMENSIONAL OBJECT

APPLICANT(S) FOR DO/EO/US

Johann Oberhofer, Jochen Weidinger, Thomas Mattes

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. ☒ This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.
2. ☐ This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.
3. ☒ This is an express request to begin national examination procedures (35 U.S.C. 371(f)). The submission must include itens (5), (6), (9) and (24) indicated below.
4. ☐ The US has been elected by the expiration of 19 months from the priority date (Article 31).
5. ☒ A copy of the International Application as filed (35 U.S.C. 371 (c) (2))
   a. ☐ is attached hereto (required only if not communicated by the International Bureau).
   b. ☒ has been communicated by the International Bureau.
   c. ☐ is not required, as the application was filed in the United States Receiving Office (RO/US).
6. ☒ An English language translation of the International Application as filed (35 U.S.C. 371(c)(2)).
   a. ☒ is attached hereto.
   b. ☐ has been previously submitted under 35 U.S.C. 154(d)(4).
7. ☐ Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371 (c)(3))
   a. ☐ are attached hereto (required only if not communicated by the International Bureau).
   b. ☐ have been communicated by the International Bureau.
   c. ☐ have not been made; however, the time limit for making such amendments has NOT expired.
   d. ☐ have not been made and will not be made.
8. ☐ An English language translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).
9. ☒ An oath or declaration of the inventor(s) (35 U.S.C. 371 (c)(4)).
10. ☐ An English language translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371 (c)(5)).
11. ☐ A copy of the International Preliminary Examination Report (PCT/IPEA/409).
12. ☒ A copy of the International Search Report (PCT/ISA/210).

Items 13 to 20 below concern document(s) or information included:

13. ☒ An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
14. ☒ An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
15. ☒ A **FIRST** preliminary amendment.
16. ☐ A **SECOND** or **SUBSEQUENT** preliminary amendment.
17. ☐ A substitute specification.
18. ☐ A change of power of attorney and/or address letter.
19. ☐ A computer-readable form of the sequence listing in accordance with PCT Rule 13ter.2 and 35 U.S.C. 1.821 - 1.825.
20. ☐ A second copy of the published international application under 35 U.S.C. 154(d)(4).
21. ☐ A second copy of the English language translation of the international application under 35 U.S.C. 154(d)(4).
22. ☒ Certificate of Mailing by Express Mail
23. ☒ Other items or information:

Form PCT/1B/308; Small Entity Statement; Form PCT/RO/101; First page of WO 01/10631 A2; Formal Drawings (4 sheets)

U.S. APPLICATION NO. (IF KNOWN, SEE 37 CFR)	INTERNATIONAL APPLICATION NO.	ATTORNEY'S DOCKET NUMBER
10/049305	PCT/EP00/07318	70301/56912

24. The following fees are submitted:.

BASIC NATIONAL FEE (37 CFR 1.492 (a) (1) - (5)) :

		CALCULATIONS PTO USE ONLY
☐	Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO and International Search Report not prepared by the EPO or JPO	**$1040.00**
☒	International preliminary examination fee (37 CFR 1.482) not paid to USPTO but International Search Report prepared by the EPO or JPO	**$890.00**
☐	International preliminary examination fee (37 CFR 1.482) not paid to USPTO but international search fee (37 CFR 1.445(a)(2)) paid to USPTO	**$740.00**
☐	International preliminary examination fee (37 CFR 1.482) paid to USPTO but all claims did not satisfy provisions of PCT Article 33(1)-(4)	**$710.00**
☐	International preliminary examination fee (37 CFR 1.482) paid to USPTO and all claims satisfied provisions of PCT Article 33(1)-(4)	**$100.00**

ENTER APPROPRIATE BASIC FEE AMOUNT =	**$890.00**	
Surcharge of **$130.00** for furnishing the oath or declaration later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492 (e)).	**$0.00**	

CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE		
Total claims	50 - 20 =	30	x $18.00	**$540.00**	
Independent claims	6 - 3 =	3	x $84.00	**$252.00**	
Multiple Dependent Claims **(check if applicable)**.			☐	**$0.00**	
TOTAL OF ABOVE CALCULATIONS =				**$1,682.00**	
☒ Applicant claims small entity status. See 37 CFR 1.27). The fees indicated above are reduced by 1/2.				**$841.00**	
SUBTOTAL =				**$841.00**	
Processing fee of **$130.00** for furnishing the English translation later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492 (f)). +				**$0.00**	
TOTAL NATIONAL FEE =				**$841.00**	
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31) **(check if applicable).** ☒				**$40.00**	
TOTAL FEES ENCLOSED =				**$881.00**	
				Amount to be: refunded	$
				charged	$

a. ☒ A check in the amount of **$881.00** to cover the above fees is enclosed.

b. ☐ Please charge my Deposit Account No. _____ in the amount of _____ to cover the above fees. A duplicate copy of this sheet is enclosed.

c. ☒ The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. **04-1105** A duplicate copy of this sheet is enclosed.

d. ☐ Fees are to be charged to a credit card. **WARNING:** Information on this form may become public. **Credit card information should not be included on this form.** Provide credit card information and authorization on PTO-2038.

NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status.

SEND ALL CORRESPONDENCE TO:

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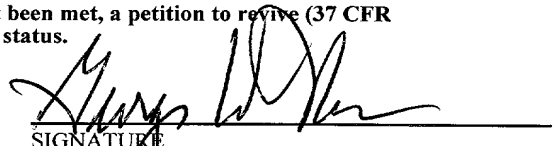

SIGNATURE

George W. Neuner

NAME

26,964

REGISTRATION NUMBER

6 Feb. '02

DATE

Attorney Docket No. 70301.56912

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

APPLICANT: OBERHOFER, Johann
WEIDINGER, Jochen
MATTES, Thomas

SERIAL NO. Entry into national stage of PCT/EP00/07318

FILED: Herewith

FOR: PROCESS AND DEVICE FOR PRODUCING A THREE DIMENSIONAL OBJECT

BOX PATENT APPLICATION
COMMISSIONER FOR PATENTS
WASHINGTON, DC 20231

Sir:

PRELIMINARY AMENDMENT

Please amend the above application as follows.

In the Claims:

Please cancel claims 1-43 and enter the following new claims.

44. A process for producing a three-dimensional object, the process comprising the steps of:

providing a container arranged within a process chamber and a carrier that can be moved in the container;

forming the object on the carrier in the container by sequential selective solidification of layers of a solidifiable powder material at positions corresponding to the cross-section of the object in the particular layer; and

controllably removing non-solidified powder material after forming the object.

45. The process according to claim 44, further comprising, after forming the object, raising the carrier successively within the container and removing the non-solidified powder material present in the region of the container rim with each successive raising of the carrier.

46. The process according to claim 44, wherein removing the non-solidified powder material is performed mechanically.

47. The process according to claim 46, wherein removing the non-solidified powder material is performed by brushes.

48. The process according to claim 44, wherein removing the non-solidified powder material is performed by a fluid.

49. The process according to claim 48, wherein removing the non-solidified powder material is performed by a gas stream.

50. The process according to claim 49, further comprising directing the gas stream essentially tangentially to the surface of the powder material.

51. The process according to claim 49, further comprising controlling the direction of the gas stream.

52. The process according to claim 51, further comprising directing the gas stream essentially tangentially to the surface of the powder material.

53. The process according to claim 49, further comprising blowing away the non-solidified powder.

54. The process according to claim 49, further comprising removing the non-solidified powder by suction.

55. The process according to claim 46, further comprising removing the non-solidified powder by suction.

56. The process according to claim 44, further comprising raising the carrier continuously after forming the object.

57. The process according to claim 44, further comprising raising the carrier stepwise after forming the object.

58. The process according to claim 44, further comprising cooling the object is cooled during removing of the non-solidified powder.

57. The process according to claim 58, further comprising directing a gas stream essentially tangentially to the powder surface to cool the object.

59. The process according to claim 44, further comprising removing the container from the process chamber after forming the object.

60. The process according to claim 44, further comprising tilting the container at a predetermined angle to the vertical after forming the object.

61. The process according to claim 60, further comprising removing the non-solidified powder and the object by raising the carrier in the container and successive overflowing of an edge of the container.

62. The process according to claim 61, further comprising providing a sieve device and separating the non-solidified powder and the object from one another in the sieve device.

63. The process according to claim 44, further comprising collecting the non-solidified powder and transporting away the non-solidified powder.

64. The process according to claim 44, further comprising treating the surface of the object during removal of the non-solidified powder material.

65. The process according to claim 48, further comprising controlling the temperature of the fluid.

66. The process according to claim 65, further comprising controlling the temperature of the fluid and the ambient temperature of the container.

67. The process according to claim 48, further comprising controlling the ambient temperature of the container.

68. The process according to claim 44, further comprising providing a source of electromagnetic radiation and solidifying the powder material under action of electromagnetic radiation.

69. A device for producing a three-dimensional object by sequential solidification of layers of a solidifiable powder material, the device comprising:

a container for accommodating the object to be produced;

a carrier that can be moved in the container; and

an apparatus for controlled removal of non-solidified powder material after producing the object.

70. The device according to claim 69, further comprising a cooling apparatus for controlled cooling of the object during the controlled removal of non-solidified powder.

71. The device according to claim 69, wherein the container has an upper rim and wherein the apparatus for controlled removal of non-solidified powder material comprises a conduit for supplying a stream of fluid essentially tangentially to the upper rim of the container.

72. The device according to claim 71, further comprising a source for providing suction for removing non-solidified powder material.

73. The device according to claim 69, further comprising a means for continuous or stepwise raising of the carrier in the container.

74. The device according to claim 69, wherein the container has an upper rim and the device further comprises an overflow region curved outwards in a region on the upper rim.

75. The device according to claim 74, further comprising means for tilting the container by a predetermined angle (A) to a vertical in the direction of the overflow device.

76. The device according to claim 75, further comprising a means for separating the non-solidified powder material from the object.

77. The device according to claim 69, further comprising means for mechanical removal of the non-solidified powder material.

78. The device according to claim 69, further comprising a chamber surrounding the container and a controller for control of the temperature surrounding the container.

79. The device according to claim 69, wherein the apparatus for controlled removal of non-solidified powder material comprises a conduit for supplying a stream of fluid to remove the non-solidified powder material and the device further comprises a controller for control of the temperature of the fluid.

80. The device according to claim 69, further comprising a conduit for supplying a stream of a gas stream to remove the non-solidified powder material.

81. The device according to claim 69, further comprising a means for automatic infiltration of the object with a material.

82. The device according to claim 81, wherein the material is wax.

83. The device according to claim 81, wherein the material epoxy resin.

84. A device for automatic unpacking and/or cooling of a three-dimensional object that is produced by sequential solidification of layers of a solidifiable powder material, the device comprising:

a container for accommodating the object to be produced;

a carrier that can be moved in the container; and

an apparatus for controlled removal of non-solidified powder material after producing the object.

85. The device according to claim 84, further comprising a cooling apparatus for controlled cooling of the object during the controlled removal of non-solidified powder.

86. The device according to claim 84 in combination a second device for producing a three-dimensional object, the device being located and arranged inside the second device.

87. The device according to claim 86, wherein the second device is a laser sintering device.

88. A device for automatic unpacking and/or cooling of a three-dimensional object that is produced by sequential solidification of layers of a solidifiable powder material, the device comprising:

a container for accommodating the object to be produced;

a carrier that can be moved in the container; and

a cooling apparatus for controlled cooling of the object during the controlled removal of non-solidified powder.

89. A process for producing a three-dimensional object, the process comprising the steps of:

providing a container arranged within a process chamber and a carrier that can be moved in the container;

forming the object on the carrier in the container by sequential selective solidification of layers of a solidifiable pulverulent material at positions corresponding to the cross-section of the object in the particular layer; and

controllably cooling of the object after forming it.

90. The process according to claim 89, wherein the cooling is effected by providing a gas to the object.

91. The process according to claim 90, wherein providing the gas comprises blowing the gas into the non-solidified powder.

92. The process according to claim 90, wherein providing the gas comprises blowing the gas over an exposed surface of the object in the powder.

93. The process according to claim 89, further comprising providing additional treatment to the object during cooling.

94. The process for producing a three-dimensional object, the process comprising the steps of:

forming the object by sequential selective solidification of layers of a solidifiable pulverulent material at positions corresponding to the cross-section of the object in the particular layer; and

subjecting the object to infiltration with a material.

95. The process according to claim 94, wherein the material is a wax.

96. The process according to claim 94, wherein the material is epoxy resin.

97. The process according to claim 94, further comprising controlling the temperature of the infiltration of the object.

REMARKS

An early examination and notice of allowance are earnestly solicited.

Respectfully submitted,

Date: 6 Feb. '02

By: ______________________
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BOS2_189066.1

EP Y83-1602.2

PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

☒ **In re application of*:** 1) Johann OBERHOFER 2) Jochen WEIDINGER 3) Thomas MATTES

Serial No.: Group No.:

Filed: Examiner:

For*: PROCESS AND DEVICE FOR PRODUCING A THREE-DIMENSIONAL OBJECT

☐ **Patent No.:** Issued:

**NOTE:* *Insert name(s) of inventor(s) and title also for patent. Where statement is with respect to a maintenance fee payment also insert application serial number and filing date and add Box M. Fee to address.*

VERIFIED STATEMENT (DECLARATION) CLAIMING SMALL ENTITY STATUS (37 CFR 1.9(c-f) and 1.27(b-d))

With respect to the invention described in

☒ the specification filed herewith.

☐ application serial no. _____, filed _____

☐ patent no. _____, issued _____

I. IDENTIFICATION OF DECLARANT AND RIGHTS AS A SMALL ENTITY

I hereby declare that I am

(complete either (a), (b), (c) or (d) below):

(a) Independent Inventor

☐ a below named independent inventor and that I qualify as an independent inventor as defined in 37 CFR 1.9(c) for purposes of paying reduced fees under Section 41(a) and (b) of Title 35, United States Code to the Patent and Trademark Office.

(b) Non-Inventor Supporting a Claim By Another

☐ making this verified statement to support a claim by

_____

for a small entity status for purposes of paying reduced fees under Section 41(a) and (b) of Title 35, United States Code and I hereby declare that I would qualify as an independent inventor as defined in 37 CFR 1.9(c) for purposes of paying reduced fees under 41(a) and (b) of Title 35, United States Code, if I had made the above identified invention.

(c) Small Business Concern

☐ the owner of the small business concern identified below:

☒ an official of the small business concern empowered to act on behalf of the concern identified below:

NAME OF CONCERN EOS GmbH Electro Optical Systems

ADDRESS OF CONCERN Pasinger Straße 2

82152 Planegg/Germany and

that the above identified small business concern qualifies as a small business concern as

defined in 13 CFR 121.3-18, and reproduced in 37 CFR 1.9(d), for purposes of paying reduced fees under Section 41(a) and (b) of tthe Title 35, United States Code, in that the number of employees of the concern, including those of its affiliates, does not exceed 500 persons. For purposes of this statement, (1) the number of employees of the business concern is the average over the previous fiscal year of the concern of the persons employed on a full-time, part-time or temporary basis during each of the pay periods of the fiscal year, and (2) concerns are affiliates of each other when either, directly or indirectly, one concern controls or has the power to control the other, or a third party or parties controls or has the power to control both.

(d) Non-Profit Organization

☐ an official empowered to act on behalf of the nonprofit organization identified below:

NAME OF ORGANIZATION _____

ADDRESS OF ORGANIZATION _____

_____

TYPE OR ORGANIZATION

☐ UNIVERSITY OR OTHER INSTITUTION OF HIGHER EDUCATION

☐ TAX EXEMPT UNDER INTERNAL REVENUE SERVICE CODE (26 USC 501(a) and 501(c) (3))

☐ NONPROFIT SCIENTIFIC OR EDUCATIONAL UNDER STATUTE OF STATE OF THE UNITED STATES OF AMERICA

(NAME OF STATE _____)

(CITATION OF STATUTE _____)

☐ WOULD QUALIFY AS TAX EXEMPT UNDER INTERNAL REVENUE SERVICE CODE (26 USC 501(a) and 501(c) (3)) IF LOCATED IN THE UNITED STATES OF AMERICA

☐ WOULD QUALIFY AS NONPROFIT SCIENTIFIC OR EDUCATIONAL UNDER STATUTE OF STATE OF THE UNITED STATES OF AMERICA IF LOCATED IN THE UNITED STATES OF AMERICA

(NAME OF STATE _____)

(CITATION OF STATUTE _____)

and that the nonprofit organization identified above qualifies as a nonprofit organization as defined in 37 CFR 1.9(e) for purposes of paying reduced fees under Section 41(a) and (b) of Title 35, United States Code.

II. OWNERSHIP OF INVENTION BY DECLARANT

I hereby declare that rights under contract or law remain with and/or have been conveyed to the above identified

☐ person	☒ concern	☐ organization
(item (a) or (b) above)	(item (c) above)	(item (d) above)

EXCEPT, that if the rights held are not exclusive, each individual, concern or organization having rights to the invention is listed below* and no rights to the invention are held (1) by any person who could not be classified as an independent inventor under 37 CFR 1.9(c) if

that person had made the invention, (2) any concern which would not qualify as a small business concern under 37 CFR 1.9(d) or (3) a non-profit organization under 37 CFR 1.9(e).

[X] no such person, concern, or organization

[ ] person, concerns or organizations listed below*

*NOTE: *Separate verified statements are required from each named person, concern or organization having rights to the invention averring to their status as small entities. (37 CFR 1.27).*

FULL NAME _____

ADDRESS _____

_____

[ ] INDIVIDUAL [ ] SMALL BUSINESS CONCERN [ ] NONPROFIT ORGANIZATION

FULL NAME _____

ADDRESS _____

_____

[ ] INDIVIDUAL [ ] SMALL BUSINESS CONCERN [ ] NONPROFIT ORGANIZATION

III. ACKNOWLEDGEMENT OF DUTY TO NOTIFY PTO OF STATUS CHANGE

I acknowledge the duty to file, in this application or patent, notification of any change in status resulting in loss of entitlement to small entity status prior to paying, or at the time of paying, the earliest of the issue fee or any maintenance fee due after the date on which status as a small entity is no longer appropriate. (37 CFR 1.28(b))

IV. DECLARATION

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application, any patent issuing thereon, or any patent to which this verified statement is directed.

V. SIGNATURES

(complete only (e) or (f) below)

(e)

NOTE: All inventors must sign the verified statement

_____
Name of Inventor

_____
Signature of Inventor Date

_____
Name of Inventor

_____
Signature of Inventor Date

_____
Name of Inventor

_____
Signature of Inventor Date

or

OR

(f)

NOTE: The title of the person signing on behalf of a concern or non-profit organization should be specified.

NAME OF PERSON SIGNING Johann Oberhofer,

TITLE OF PERSON COO

(if signing on behalf of a concern or non-profit organization)

ADDRESS OF PERSON SIGNING Pasinger Straße 2

82152 Planegg/ Germany

SIGNATURE [signature] DATE 27-11-01

Docket No. 70301/56912

Express Mail Label No. EL 789783138US

10/049305

JC13 Rec'd PCT/PTO 06 FEB 2002

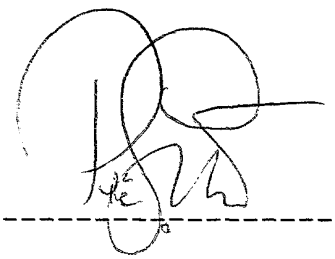
VERIFICATION OF TRANSLATION

I, Peter Gabriel, of 12 Sylvan Road, London SE19 2RX, England, do hereby verily declare that the attached document is a true translation of International Patent Application No. PCT/EP00/07318

for: Process and device for producing a three-dimensional object.

made by: EOS GmbH Electro Optical Systems
Pasinger Strasse 2
82152 Planegg/Germany

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon. .



Date: 10.12.2001

Process and device for producing a three-dimensional object

The invention relates to a process for producing a three-dimensional object according to the preamble of patent claim 1 or 38 or 41 and a device for producing a three-dimensional object according to the preamble of patent claim 23 or a device according to the preamble of patent claim 36.

In a process, known for example from United States 4 863 538, for producing a three-dimensional object by means of selective laser sintering, the object is produced by successive selective solidification of layers of a pulverulent material at positions corresponding to the object in the particular layer under the action of a laser beam. The objects thus produced are still hot immediately after they are completed and do not yet have their final solidity. Furthermore, the object must be freed of non-solidified powder before it may be used. Depending on application, it is also desirable or necessary to subsequently treat the objects.

A process and a device according to patent claim 1 or 15 is known from United States 5 846 370. There it is proposed to construct the object in a container which is provided within a process chamber and after completing the object may be removed from the latter and may be used as a cooling device. It is known from European 0 632 761 to also solidify a container wall surrounding the object together with the object and to place this container thus formed together with the object at a separate location for cooling after the building process. It is known from European 0 289 116 to produce an object by means of laser sintering of a powder, wherein the powder layers are applied by means of a fluidised bed process. Heated or cooled gas is supplied in order to keep the object at a uniform temperature during the building process. It is known from European 0 287 657 to pass a stream of temperature-controlled air through the powder bed, in order to remove heat from the object during the building process.

It is also known from German utility model DE 29 506 716.6 to remove or to unpack an object produced by means of selective laser sintering manually from the non-solidified

powder still surrounding the object after construction. It is known from WO 00/21673 to provide a changeable building frame for the object in a laser sintering device which can be removed quickly and simply from the laser sintering device and re-installed and hence facilitates rapid job change. A device and a process is known from United States 5 569 431, in which an object formed by means of stereolithography is automatically raised up from a bath of liquid material which can be photo-solidified. Furthermore, European 0 403 146 discloses a stereolithography device, in which a device in which the object is constructed and a subsequent treatment device are provided. A transport device for transporting the object between the two is also provided.

It is the object of the invention to provide a process and a device for producing a three-dimensional object from solidifiable powder material, with which the overall production process may be simplified, automated and/or shortened and the precision during the production of the object is improved.

The object is achieved by a process according to patent claim 1 or 38 or 41 and a device according to patent claim 23 or 36. Further developments of the invention are given in the sub-claims.

Further features and advantages of the invention can be seen from the description of exemplary embodiments using the figures.

Of the figures

Figure 1 shows a schematic sectional view of the device of the invention;

Figure 2 shows a schematic sectional view of a detail of the device according to a first embodiment of the invention;

Figure 3 shows a schematic sectional view of a detail of the device according to a second embodiment of the invention;

Figure 4 shows a schematic sectional view of a detail of the device according to a further embodiment of the invention; and

Figure 5 shows a schematic sectional view of a detail of the device according to a still further embodiment of the invention.

As can be seen in particular from Figure 1, the device for producing a three-dimensional object has a container open at the top or building container 1 having an upper rim 2. The cross-section of the container 1 is greater than the largest cross-sectional surface area of an object 3 to be produced. A carrier 4 for supporting the object to be formed having an essentially flat surface 5 facing the upper rim 2 is provided in the container 1. The carrier 4 can be moved up and down in the container 1 in vertical direction by means of a drive indicated schematically in Figure 1. The upper rim 2 of the container 1 defines a working plane 6.

The container 1 is releasably attached in a process chamber 100, so that it can be removed from the process chamber 100 together with the object 3 formed therein.

A radiation device in the form of a laser 7, which emits a directed light beam 8, is arranged above the working plane 6. A deflecting device 9 is provided, for example as a system of galvanometer mirrors, by means of which the light beam 8 as deflected beam 8' can be deflected to each required position of the working plane 6.

A coater 10, for applying a layer of a powder material 11 to be solidified to the carrier surface 5 or a layer which is solidified in the end, is provided. The coater 10 can be moved back and forth over the working plane 6 by means of a schematically indicated drive from a first end position on one side of the container 1 to a second end position on the opposite side of the container 1.

A control device 40 is also provided, by means of which the drive to set the position of the carrier 4, the drive for moving the coater 10 and the drive for adjusting the deflecting device can be controlled in coordinated manner or independently of one another.

In a first embodiment of the invention shown in Figure 2, the device for producing the object has a device 50 preferably arranged outside the process chamber 100 for controlled removal of the complete object from the container 1. The device 50 has a mounting 51 shown only schematically, in which the container 1 can be inserted and is held, after it is removed from the process chamber. The device 50 also has a drive indicated schematically in Figure 2 for upward and downward movement of the carrier in the device 50. The drive is designed such that the carrier may be moved at an adjustable rate continuously or stepwise against the upper rim 2 of the container. Furthermore, the drive is designed so that the carrier 4 may be lowered again after it has reached its uppermost position.

A covering 52 sealing the container 1 from the surroundings at its open side is also provided in the form of a dome-like hood, which rests with its lower rim on the upper rim 2 of the container 1. The covering 52 can be placed on the container and a seal is provided between the upper rim 2 of the container 1 and the covering, by means of which seal a hermetic seal to the atmosphere is guaranteed. The covering has two openings 53 and 54 opposite one another which are provided at a predetermined distance from the lower rim of the covering 52. The openings 53, 54 are in each case connected to a supply pipe 55 or a removal pipe 56 for supplying a compressed gas or for removing the gas and powder particles fluidised by the gas stream. The supply pipe 55 is connected to a device 57 for supplying a gaseous medium preferably with a compressed air source 57. The removal pipe 56 is connected to a collection container 58 for removed powder material. The openings 53 and 54 in the covering 52 are arranged such that when the compressed air source 57 is connected, a gas stream flowing essentially tangentially over the upper rim 2 of the container is produced. The compressed air source 57 can be adjusted so that the strength of the air stream can be controlled. Furthermore, the temperature of the gaseous medium can be controlled so that a temperature required for cooling can be set.

In the process of the invention, the object is initially produced in known manner on the carrier 4 within the container 1 in the process chamber 100. Hence, the carrier 4 is first moved to the highest position, in which the carrier surface 5 lies at a distance of one layer thickness of the first layer to be applied below the upper rim 2 of the container 1. The coater 10 is then moved over the working plane 6 and a first layer of powder 11 to be solidified is applied. The deflecting device 9 is then controlled such that a region of the powder material corresponding to the cross-section of the object in this layer is solidified by the laser beam 8. The carrier 4 is then lowered and a new layer applied and likewise again solidified. These steps are repeated so often until the object 3 is completed. Plastic powder, such as for example polyamide powder, metal powder, ceramic powder, plastic-coated sand or combinations thereof, is used as powder material 11, depending on the area of application.

The container is then removed from the process chamber 100 together with the object 3 formed therein and introduced into the device 50 for unpacking the object 3. The carrier 4 is thus situated within the container 1 in its lowest position. Powder material 11 which is not yet solidified is situated between the object 3 formed and the container wall. When using plastic powder, the object 3 is typically still hot immediately after being completed and has not yet reached its final solidity. For gentle unpacking and cooling of the object, the covering 52 is now placed on the container 1 and the compressed air source 57 is connected. The carrier 4 is then moved upwards either continuously at an adjustable rate or stepwise within the container, so that a quantity of non-solidified powder is always situated above the container rim 2 and is held by the covering 52. The compressed air source 57 is adjusted so that an adequately strong air stream passes essentially tangentially over the powder surface and thus entrains non-solidified powder, which is removed through the outlet opening 53 and the removal pipe 56 and is collected in the collection container 58. As soon as the object 3 arrives within the region of the air stream passing over the surface by raising the carrier 4, it is cooled by the air stream. When the carrier 4 is in its uppermost end position, the covering 52 is removed and the object is taken out. It is thus adequately cooled. Hence, the object 3 is removed from the container

1 in predetermined manner by adjusting the temperature and the pressure of the air stream, and the moving rate of the carrier within the container in predetermined manner and the container 1 is again free for new insertion in the process chamber 100. The process has the advantage that by controlled unpacking and cooling of the object 3, sudden cooling is avoided and at the same time the non-solidified powder material is removed and cooled likewise slowly and in controlled manner, so that it has a high quality for re-use. On the other hand, the object 3 is only removed after this procedure, so that it does not have to be touched in the hot and still soft state, and thus is not exposed to deforming forces. Furthermore, cooling and unpacking outside the process chamber has the advantage that the latter is free for forming new objects.

In an alternative embodiment, a suction pump, which assists transport of the non-solidified powder, is connected to the removal pipe 56. The air may also be circulated, a connection pipe is then provided for this between the air removal pipe 56 and the air supply pipe 55, in which a filter is arranged to separate fluidised powder and air. Instead of air, a further gas, for example a protective gas, such as nitrogen, may also be used to prevent the powder, for example from oxidising. The overall device 50 may also be arranged within the process chamber 100, wherein however, the process chamber is then occupied during unpacking and cooling.

In a modification of the embodiment according to Figure 2, instead of openings 53, 54, more than two openings are provided in different positions. The gas stream may also be directed other than tangentially to the surface. Furthermore, a device is provided to control the direction of the gas stream, for example in the form of a controllable nozzle.

In a further embodiment shown in Figure 3 of an device for removing the object from the building container, the container 200 is designed such that it has a frame 60 having preferably square or rectangular cross-section, within which the carrier 4 can be moved up and down. An annular or collar-like attachment or rim 62 is provided, which can be placed on the upper rim 61 of the container frame 60 and can be removed again. The attachment 62 is designed such that it forms an overflow device, preferably in an

outwardly curved overflow edge 63 or an overflow rim rounded in the region of the overflow on at least one of the four sides of the container frame 60, and projects on the other three sides beyond the rim 61 of the container frame 60, so that it forms a device at the top for preventing powder or object from falling out during movement of the carrier 4. The container 200 is held by its frame 60 in a mounting 70, which is preferably arranged outside the process chamber 100. A tilting device 71 is also provided, with which the container 200, together with its mounting 70, can be tilted in vertical direction about a predetermined and adjustable angle A, so that the displacement axis V of the carrier 4 in the container 1 is tilted by this predetermined angle A with respect to the vertical.

A sieve device 80, preferably in the form of a shaking sieve, is arranged below the overflow edge 63 of the container 1 and a collection container 90 is arranged below the shaking sieve.

In a modification of the embodiment according to claim 3, the container 1, the sieve device 80 and optionally the collection container 90 are arranged in a dust-tight and optionally gas-tight chamber in order to avoid dust and to facilitate the control of the temperature of the surroundings.

In the process according to this embodiment, first of all the object 3 is completed within the process chamber as described above. It is thus quite possible that several separate objects 3, 3', 3'' are produced within the container, which are separated from one another by non-solidified powder material 11.

The container 200 is then removed from the process chamber and placed in the mounting 70 of the device 500 for unpacking. The container 200 is tilted by means of the tilting device 71 such that the axis V of the carrier 4 has a predetermined angle A to the vertical in the direction of the sieve or collection device 80. The carrier 4 is then raised continuously or stepwise, so that non-solidified powder material 11 is pushed over the overflow edge 63 and then falls on the shaking sieve 80. The mesh width of the sieve 80

is selected such that non-solidified powder may be sifted off and collected and transported away for re-use in the collection container 90. The object or objects formed are also pushed over the overflow edge 3 by the pressure of the following powder material pushed over the overflow edge 63 by the carrier 4 moving upwards and collected in the shaking sieve 80, from where they may then be removed after sifting off the non-solidified powder material. The tilting angle A may be changed, for example increased, during raising of the carrier 4, so that the powder and the objects may be pushed completely from the container over the overflow edge 63. The container 200 does not necessarily have to be tilted. Controlled unpacking, that is the controlled removal of non-solidified powder material, is crucial.

In this embodiment, it is also possible to provide a cooling device, for example in the form of an air or gas stream G passing along the powder surface, as a result of which objects emerging on the powder surface and the powder itself are cooled.

A combination of the embodiments shown in Figure 2 and Figure 3 for the device for unpacking are also possible. Overflow of the powder over the edge 63 may be assisted, for example by compressed air or by a vibrator provided on the overflow edge, the container or the carrier.

In a further embodiment, a device is provided, with which the non-solidified powder is removed mechanically in controlled manner. Such a device may be formed, for example by one or more brushes, by means of which non-solidified powder is conveyed away from the surface during the upward movement of the carrier in the container, and optionally powder residues adhering to the object are removed. The mechanical device for removing the powder may also be used for assisting powder removal during sieving.

Moreover, the invention is not restricted to the use of a gas stream for removing non-solidified powder material. It is also possible to use a different fluid medium instead of the gas stream, for example a gas/powder mixture, a liquid or a liquid/powder mixture. By using a suitable fluid medium, it is possible to treat the surface of the component at

the same time as removing the powder, for example to bring about smoothing by means of a gas/powder stream or hardening by means of reactive gases. Such a subsequent treatment of the component may take place at the same time and automated with the removal of powder in the device for removing the object from the container or after powder removal.

Both the embodiment according to Figure 2, and that according to Figure 3 or combinations of the same may also have additionally a temperature control device for controlling the temperature of the fluid medium or of the gas stream and/or the surrounding atmosphere. In a step for controlling temperature for controlled cooling of the object formed, the ambient temperature corresponds initially to the object temperature and is then slowly reduced during sieving.

In a further embodiment, which is shown in Figure 4, the carrier surface 5, also designated as building platform, on which the object is constructed in a container 300, is designed to be porous, as shown in the left-hand half of Figure 4, or equipped with openings 500, as shown in the right-hand half of Figure 4. A gas, for example air, which produces a type of fluidised bed and which loosens the powder 11 surrounding the object, is blown in from below through the porous building platform or the openings. Compactions or lumps which possibly exist are thus loosened, which facilitates unpacking, The direction, flow, rate and temperature of the gas can be controlled individually or in combined manner. Hence, the temperature of the whole powder bed, including the object, may be controlled. This embodiment can be combined with the exemplary embodiments described hitherto for unpacking the object. Alternatively or additionally to blowing in through the carrier surface 5, the gas may also be blown into the powder bed through the side walls of the container 300 or from the top.

Figure 5 shows a device for controlled cooling of the object as a further embodiment of the invention. One or more supply devices 600 for gas in the form of probes or similar are passed through the building platform 5 and/or the side walls and/or the upper powder surface of the container 300, wherein the position known from CAD data and geometry

of the particular object 3 is taken into account. Gas is passed at controlled temperature through the supply devices 600, so that the object may be cooled by local specific convection under defined temperature conditions. The gas also loosens the powder bed, as a result of which unpacking is facilitated.

Depending on the powder material used, the building process may be carried out, so that the object is not hot immediately after completing and therefore does not require cooling. Here too, the processes and devices described have the advantage that the object is unpacked gently and without manual work. If the object already has adequate solidity immediately after completing, instead of the continuous or stepwise raising of the carrier, the whole content of the container may be emptied straight onto the sieve or collection device, for example by opening the container. This alternative has the advantage that the entire process is accelerated, wherein the process and means described above for powder removal and cooling may likewise be used.

It is crucial that means for controlled removal of the non-solidified powder material are provided, which faciliate automatic unpacking of the object formed from the container in controlled manner without manual work.
A further embodiment of the invention consists in specifically influencing the object properties by controlled unpacking and/or cooling by means of a gas or a fluid medium, which renders manual subsequent treatment superfluous. Chemical subsequent treatment of the surface of the object formed may for example take place with the blowing-in of gas. Hence, the conventional production steps between production and use of the object can be accelerated. According to a further embodiment of the invention, the object, after non-solidified powder has been removed, is automatically subsequently treated, for example subjected to infiltration using wax or epoxy resin. The temperature of the building chamber is thus set to a suitable value necessary for infiltration via the temperature control.

The invention is also not restricted to the fact that a laser beam is used for solidifying the powder material. Instead of using a laser beam, the powder may also be solidified in a

different manner, for example using other energy beams, such as for example using an electron beam or by selective adhesion, for example using binder or adhesive selectively injected from a printer head.

PATENT CLAIMS

1. Process for producing a three-dimensional object having the steps forming the object (3) in a container (1, 200) arranged within a process chamber (100) on a carrier (4) which can be displaced in the container by sequential selective solidification of layers of a solidifiable pulverulent material (11) at positions corresponding to the cross-section of the object in the particular layer, characterised by the step of controlled removal of non-solidified pulverulent material (11) after completing the object (3).

2. Process according to claim 1, characterised in that after completing the object (3), the carrier (4) is raised successively within the container (1, 200) and in that non-solidified powder material present in the region of the container rim (2, 61) is removed.

3. Process according to claim 1 or 2, characterised in that the non-solidified powder material is removed mechanically.

4. Process according to claim 3, characterised in that the non-solidified powder material is removed by means of brushes.

5. Process according to one of claims 1 to 4, characterised in that the non-solidified powder material is removed by means of a fluid medium.

6. Process according to claim 5, characterised in that the non-solidified powder material is removed by means of a gas stream.

7. Process according to claim 6, characterised in that the gas stream is directed essentially tangentially to the surface of the powder.

8. Process according to claim 6 or 7, characterised in that the direction of the gas stream is controlled.

9. Process according to one of claims 6 to 8, characterised in that the non-solidified powder (11) is blown away.

10. Process according to one of claims 6 to 9, characterised in that the non-solidified powder (11) is removed by suction.

11. Process according to one of claims 1 to 10, characterised in that the carrier (4) is raised continuously after completing the object.

12. Process according to one of claims 1 to 10, characterised in that the carrier is raised stepwise after completing the object.

13. Process according to one of claims 1 to 12, characterised in that the object (3) is cooled during removal of the non-solidified powder (11).

14. Process according to claim 13, characterised in that the object (3) is cooled by a gas stream directed essentially tangentially to the powder surface.

15. Process according to one of claims 1 to 14, characterised in that the container (1, 200) is removed from the process chamber (100) after completing the object.

16. Process according to one of claims 1 to 15, characterised in that the container (1, 200) is tilted at a predetermined angle to the vertical after completing the object (3).

17. Process according to claim 16, characterised in that the non-solidified powder (11) and the object (3) formed are removed by raising the carrier in the container and successive overflowing over a container edge.

18. Process according to claim 17, characterised in that the non-solidified powder (11) and the object (3) are separated from one another in a sieve device (80).

19. Process according to one of claims 1 to 18, characterised in that removed non-solidified powder (11) is collected and transported away.

20. Process according to one of claims 1 to 19, characterised in that the surface of the object is subsequently treated during removal of the non-solidified powder material.

21. Process according to one of claims 5 to 20, characterised in that the temperature of the fluid medium and/or the ambient temperature of the container is controlled.

22. Process according to one of claims 1 to 21, characterised in that the powder material is solidified under action of electromagnetic radiation.

23. Device for producing a three-dimensional object by sequential solidification of layers of a solidifiable powder material having a container (1; 200) for accommodating the object (3) to be produced, a carrier (4) which can be displaced in the container, and a device (50; 500) for controlled removal of non-solidified pulverulent material (11) after completing the object (3).

24. Device according to claim 23, characterised in that a device for controlled cooling of the object (3) during the controlled removal of non-solidified pulverulent material is provided.

25. Device according to claim 23 or 24, characterised in that the device (50; 500) for controlled removal of non-solidified pulverulent material (11) has means for directing a stream of fluid medium essentially tangentially to the upper rim of the container (1; 200).

26. Device according to claim 25, characterised in that a device is provided for removing non-solidified powder material by suction.

27. Device according to one of claims 23 to 26, characterised in that the device (50; 500) for controlled removal of non-solidified pulverulent material (11) has means for continuous or stepwise raising of the carrier (4) in the container (1; 200).

28. Device according to one of claims 23 to 27, characterised in that the container (200) has an overflow device (63) curved outwards in a region on its upper rim (61).

29. Device according to claim 28, characterised in that means (71) are provided for tilting the container by a predetermined angle (A) to the vertical in the direction of the overflow device (63).

30. Device according to claim 29, characterised in that means are provided for separating the non-solidified powder material (11) removed from the container (200) over the overflow edge (63) and the object (3) formed.

31. Device according to one of claims 23 to 30, characterised in that the device (50; 500) is provided for controlled removal of non-solidified pulverulent material (11) outside the process chamber (100), in which the object is formed.

32. Device according to one of claims 23 to 31, characterised in that a device is provided for mechanical removal of the non-solidified powder material.

33. Device according to one of claims 23 to 32, characterised in that a device is provided for control of the temperature of the atmosphere surrounding the container and/or of the medium used to remove the non-solidified powder material.

34. Device according to one of claims 23 to 33, characterised in that a device is provided for supplying gas (5; 500; 600) to the powder bed.

35. Device according to one of claims 23 to 34, characterised in that a device is provided for automatic infiltration of the object formed with a material, preferably wax or epoxy resin.

36. Device for automatic unpacking and/or cooling of a three-dimensional object, which is produced by sequential solidification of layers of a solidifiable powder material, having a container (1; 200) for accommodating the object (3) to be produced, a carrier (4) which can be displaced in the container and having a device (50; 500) for controlled removal of non-solidified pulverulent material (11) after completing the object (3) and/or having a device for controlled cooling of the object formed (500; 600).

37. Device according to claim 36, characterised in that it is provided in a device for producing a three-dimensional object, in particular a laser sintering device.

38. Process for producing a three-dimensional object having the steps
forming the object (3) in a container (1, 200; 300) arranged within a process chamber (100) on a carrier (4) which can be displaced in the container by sequential selective solidification of layers of a solidifiable pulverulent material (11) at positions corresponding to the cross-section of the object in the particular layer, characterised by the step of controlled cooling of the object (3) after completing.

39. Process according to claim 38, characterised in that cooling is effected by means of a gas, which is preferably blown into the powder bed of the still non-solidified powder (11), or is blown over the exposed surface of the object (3) in the powder bed.

40. Process according to claim 38 or 39, characterised in that the object is subsequently treated during cooling.

41. Process for producing a three-dimensional object having the steps: forming the object (3) by sequential selective solidification of layers of a solidifiable pulverulent material (11) at positions corresponding to the cross-section of the object in the particular layer, characterised in that the object formed is automatically subjected to infiltration.

42. Process according to claim 41, characterised in that infiltration takes place using wax or epoxy resin.

43. Process according to claim 41 or 42, characterised in that infiltration takes place in temperature-controlled manner.

ABSTRACT

A process is provided for producing a three-dimensional object having the steps forming the object (3) in a container (1, 200) arranged within a process chamber (100) on a carrier (4) which can be displaced in the container by sequential selective solidification of layers of a pulverulent material (11) which can be solidified by the action of electromagnetic or particle radiation at positions corresponding to the cross-section of the object in the particular layer, characterised by the step of controlled removal of non-solidified pulverulent material (11) after completing the object (3).

(Figure 3)

FIG.1

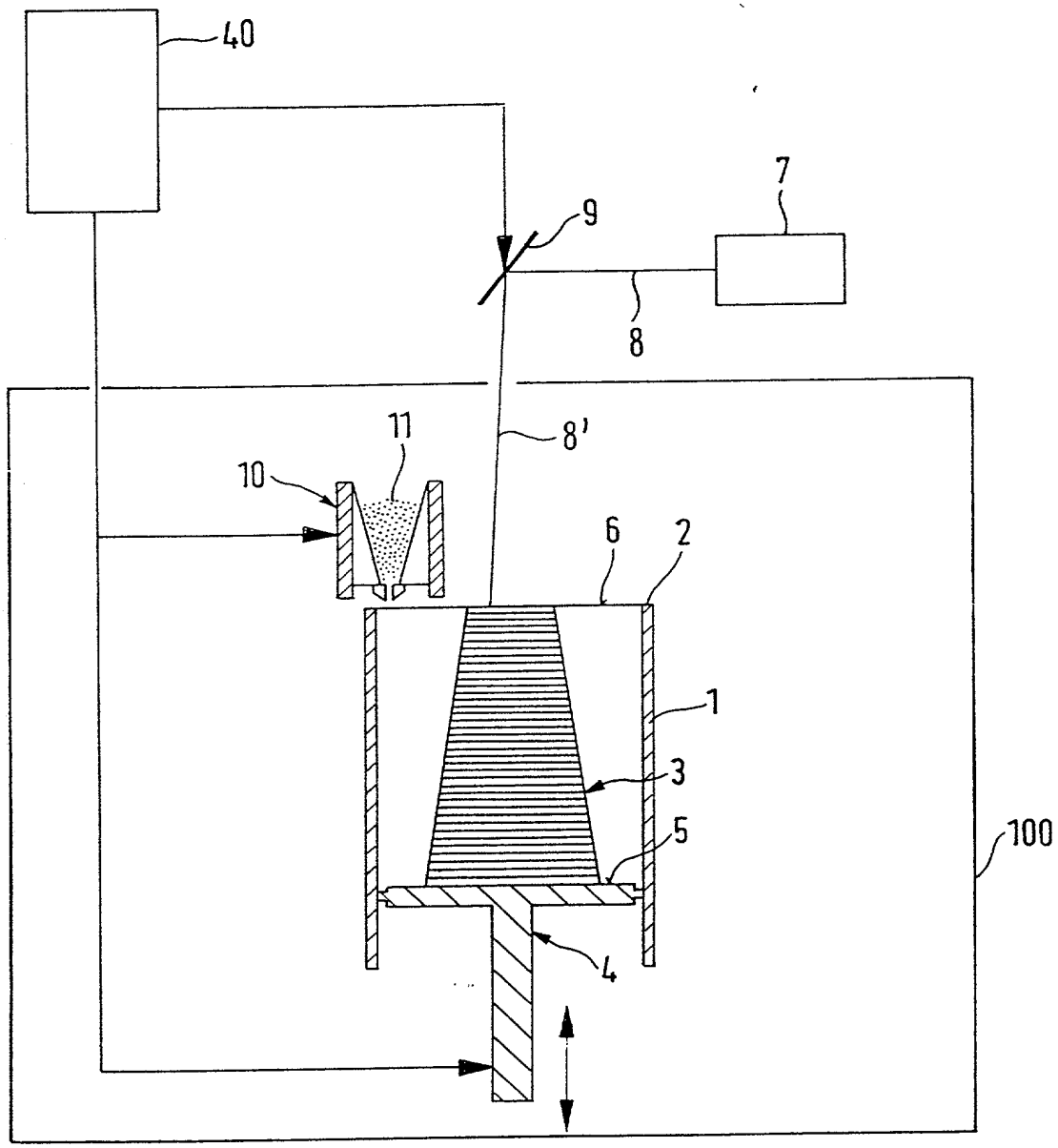


FIG. 2

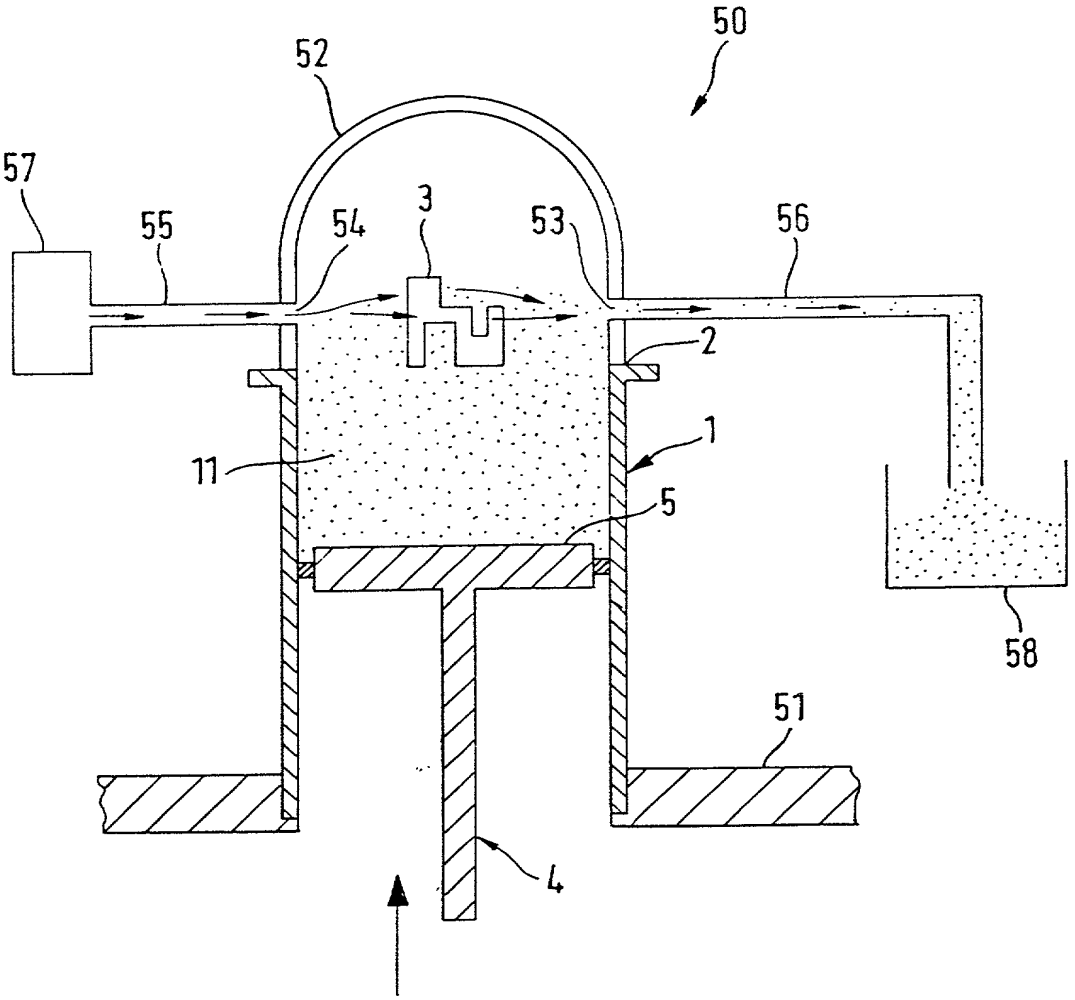
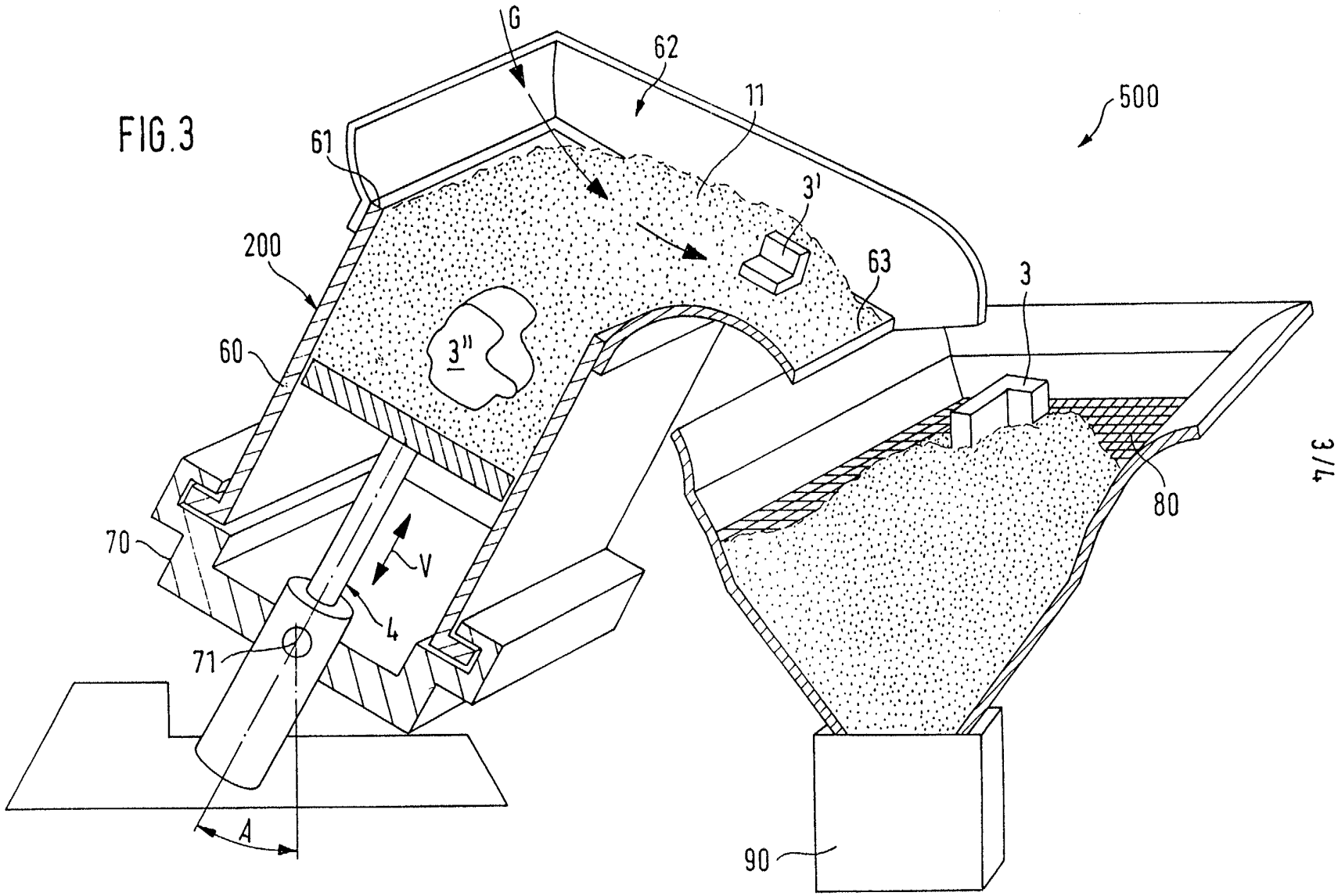


FIG.3



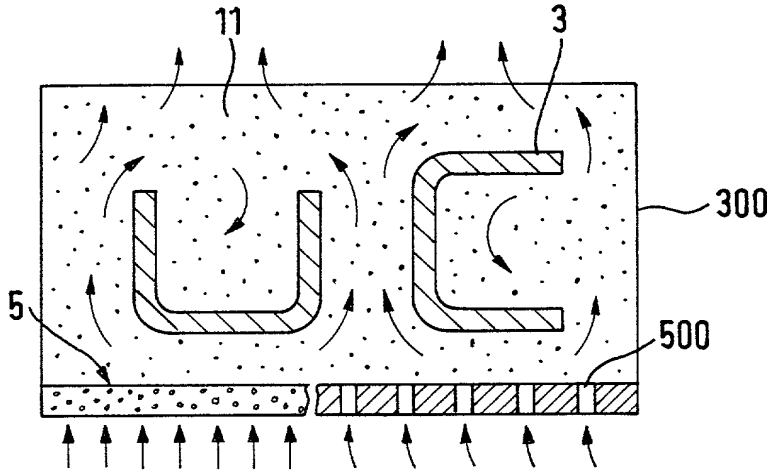


FIG.4

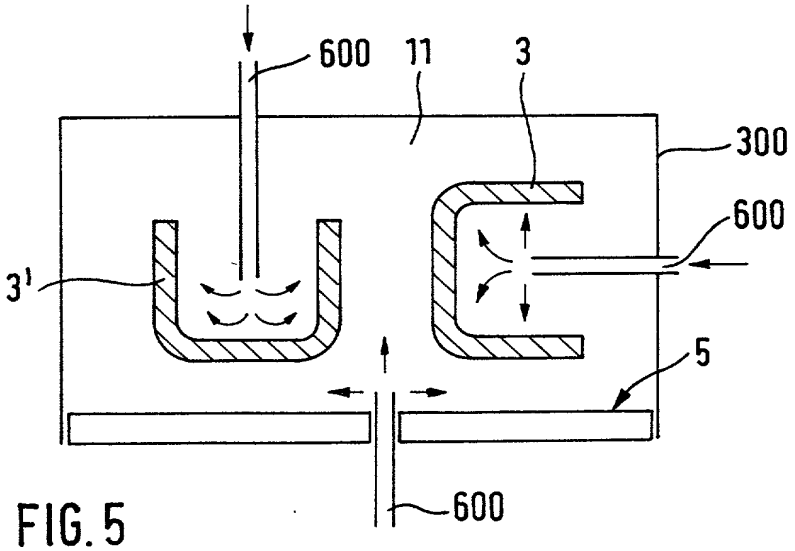


FIG.5

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Docket No.
70301/56912

DECLARATION AND POWER OF ATTORNEY

As a below named inventor, I hereby declare that: My residence, post office address and citizenship are as stated below next to my name. I believe I am the original, first and sole inventor (if only one name is listed at 201) below or an original, first and joint inventor (if plural names are listed at 201-206 below) of the subject matter which is claimed and for which a patent is sought on the invention entitled: PROCESS AND DEVICE FOR PRODUCING A THREE-DIMENSIONAL OBJECT

which is described and claimed in:

☒ the specification attached hereto.

☐ the specification in U.S. Application Serial Number _____, filed on _____.

☐ the specification in PCT international application Number, filed on _____; and was amended on _____.

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above. I acknowledge the duty to disclose information which is material to the examination of this application in accordance with Title 37, Code of Federal Regulations, §1.56(a). I hereby claim foreign priority benefits under Title 35, United States Code, §119 of any foreign application(s) for patent or inventor's certificate listed below and have also identified below any foreign application for patent or inventor's certificate having a filing date before that of the application on which priority is claimed.

Prior Foreign/PCT Applications and Any Priority Claims Under 35 U.S.C. §119:			
Application No.	**Filing Date**	**Country**	**Priority Claimed Under 35 U.S.C. §119?**
199 37 260.8	August 6, 1999	Germany	☒YES ☐NO
			☐YES ☐NO
			☐YES ☐NO

I hereby claim the benefit under 35 U.S.C. §120 of any United States application(s) or PCT international application(s) designating the United States of America that is/are listed below, and, insofar as the subject matter of each of the claims of this application is not disclosed in that/those prior application(s) in the manner provided by the first paragraph of 35 U.S.C. §112, I acknowledge the duty to disclose material information as defined in 37 CFR §1.56(a) which occurred between the filing date of the prior application(s) and the national or PCT international filing date of this application:

Prior U.S. Applications or PCT International Applications Designating the U.S-Benefit Under 35 U.S.C. §120					
U.S. Applications			**Status (Check One)**		
Application Serial No.	**U.S. Filing Date**		**Patented**	**Pending**	**Abandoned**
PCT Applications Designating the U.S.					
Application No.	**Filing Date**	**U.S. Serial No. Assigned**			
PCT/EP00/07318	July 28, 2000				

CLAIM FOR BENEFIT OF PRIOR U.S. PROVISIONAL APPLICATION(S)
(35 U.S.C. §119(e))

I hereby claim the benefit under Title 35, United States Code, §119(e) of any United States provisional application(s) listed below:

Applicant	Provisional Application Number	Filing Date

POWER OF ATTORNEY: As a named inventor, I hereby appoint the following attorney(s) with full powers of association, substitution and revocation to prosecute this application and transact all business in the Patent and Trademark Office connected therewith.

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	POST OFFICE ADDRESS	POST OFFICE ADDRESS	CITY	STATE OR COUNTRY AND ZIP CODE

I hereby further declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further, that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Signature of Inventor **201**	Signature of Inventor **202**
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Signature of Inventor **203**	Signature of Inventor **204**
Date: 03.12.01	Date:
Signature of Inventor **205**	Signature of Inventor **206**
Date:	Date: